

Journal Pre-proof

Digital competencies: A review of the literature and applications in the workplace

Maren Oberländer, Andrea Beinicke, Tanja Bipp



PII: S0360-1315(19)30305-7

DOI: <https://doi.org/10.1016/j.compedu.2019.103752>

Reference: CAE 103752

To appear in: *Computers & Education*

Received Date: 17 June 2019

Revised Date: 18 September 2019

Accepted Date: 6 November 2019

Please cite this article as: Oberländer M., Beinicke A. & Bipp T., Digital competencies: A review of the literature and applications in the workplace, *Computers & Education* (2019), doi: <https://doi.org/10.1016/j.compedu.2019.103752>.

This is a PDF file of an article that has undergone enhancements after acceptance, such as the addition of a cover page and metadata, and formatting for readability, but it is not yet the definitive version of record. This version will undergo additional copyediting, typesetting and review before it is published in its final form, but we are providing this version to give early visibility of the article. Please note that, during the production process, errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

© 2019 Published by Elsevier Ltd.

Digital competencies: A review of the literature and applications in the workplace

Maren Oberländer^{a*}, Andrea Beinicke^a, Tanja Bipp^a

^aDepartment of Psychology, Julius-Maximilians-University, Röntgenring 10, 97070 Würzburg, Germany

^aCorrespondence concerning this article should be addressed to

Maren Oberländer

Department of Psychology, Chair in Psychology II

Röntgenring 10, 97070 Würzburg, Germany,

maren.oberlaender@uni-wuerzburg.de

Telephone: +49 931 31 85825

Declaration of interests: None.

Acknowledgements

The authors thank the master students in the seminar “Digital competencies at work” for conducting the interviews with the practitioners and for helping to cluster the answers. The authors also thank the practitioners who took the time to answer the interview questions patiently and enrich the research with their insights. Furthermore, we appreciate the help and feedback by the participants of the Hot-Topic Session “Digital competencies at the workplace” at the Summer School entitled “Reading and Learning in the Digital World”.

Funding information: This work was funded by the European Union project “Individualisierung Digital” [Fonds 823881 in the Europäischer Fonds für regionale Entwicklung. (The funding source had no involvement in study design, in the collection, analysis and interpretation of data, in the writing of the report, or in the decision to submit the article for publication.)

Abstract

In today's organisations and politics, there is a growing awareness of the gap between existing and needed digital competencies of the workforce to master the challenges of the digitalised future at work. Nevertheless, no comprehensive framework or definition of digital competencies at work has been proposed so far. Our aim is to offer a holistic view and broaden the scope of the concept of digital competencies, thereby focussing on applications at work. We combine diverse methods to integrate different perspectives on digital competencies. By conducting an extensive literature review about definitions and frameworks of digital competencies that might be applicable at work, we provide an overview of the current state of the art in research on digital competencies. Additionally, eleven half-structured interviews based on the critical incidents technique (CIT) were conducted to gain insights into the perspectives of professionals with expertise in digitalisation processes and digital competencies. Subsequently, researchers with different educational backgrounds clustered the results from both approaches and agreed on twenty-five dimensions that constitute digital competencies for white-collar workers with office jobs, encompassing a large variety of knowledge, skills, and abilities. The results of this research indicate that even though there is overlapping content, each perspective adds unique content to the concept of digital competencies at work. By creating a coherent and detailed framework and a definition, our research enhances the applicability of professional learning and development of digital competencies at work.

Keywords: digital competencies; review; workplace; lifelong learning

Digital competencies: A review of the literature and applications in the workplace**1. Introduction**

Beyond the huge impact of the ongoing digitalisation in our society on our everyday life, new technologies also have a tremendous impact on the way we work (e.g., Murawski & Bick, 2017; Zaphiris & Ioannou, 2016). Devices and software programmes used in professional contexts are constantly renewed to be more efficient and to facilitate work. These changes call for increasing usage of digital information and communication technology (ICT) at work. Indeed the majority of employees today use digital ICT at work, as confirmed by 83% of the participants in a large representative German workforce sample (Arnold, Butschek, Steffes, & Müller, 2015). Most workplaces require at least basic digital competencies (Gallardo-Echenique, de Oliveira, Marques-Molias, & Esteve-Mon, 2015), already in 2006, the European Parliament and the Council identified digital competence as one out of eight key competences for lifelong learning (Ferrari, 2012; van Laar, van Deursen, van Dijk, & de Haan, 2017). In detail, they defined competence as a combination of knowledge, skills and attitudes, and digital competence as “the confident and critical use of Information Society Technology for work, leisure and communication” (Søby, 2013, p. 135).

Therefore, employees have to engage in lifelong learning, and acquire new competencies to adapt to the constantly increasing demands of the fast-changing work environment (e.g., Ahmad, Karim, Din, & Albakri, 2013; Carnevale & Smith, 2013; Cascio & Montealegre, 2016). Indeed, there seems to be a gap between existing and needed digital competencies (DC) of the workforce (e.g., Ancarani & Di Mauro, 2018; Janssen et al., 2013). In the study of Arnold and colleagues (2015), over two-thirds of the interviewed workers indicated that they constantly needed to develop further their competencies at work because of technical innovations. Even though politics and employers are aware of this issue, scientific research focusing on the DC of workers is still scarce (Murawski & Bick, 2017).

1.1. Purposes of this article

The goal of this research is to foster the understanding and add essential knowledge about conceptualizations and theories of DC at work. Therefore, we provide an overview of existing

definitions and frameworks with a focus on evaluating their potential applications at work in a literature review. Afterwards, we aim to address the science-practice gap in this field by developing essential dimensions of DC for white-collar workers that are not only based on the literature but also on insights of working practitioners.

2. Review of the literature on digital competencies

2.1. Method

2.1.1. Identification of relevant studies and search process

At first, we screened the literature for definitions and frameworks of DC to get an overview of the existing literature. In detail, we conducted a database search of *PsycINFO*, *SocINDEX*, *Psyindex*, and *ERIC* using keywords like *digital competence*, *digital literacy*, and *ICT literacy*. Only publications including the keywords in the publication title or abstract were selected. Then, we looked at the reference lists of the selected publications and added relevant publications. Additionally, given our focus on the workplace, we screened the top tier journals in applied psychology according to the SSCI Index (1. quartile) for articles that could add to the clarification of the concept of DC at work. However, this search strategy led only to a limited number of publications in peer-reviewed journals ($n = 5$). Therefore, we decided to use the portal Google Scholar to search for additional literature, and considered non-reviewed references, too (e.g. policy reports). In total, we found 142 relevant publications that were published before September 2018.

2.1.2. Inclusion criteria for article selection

We screened the 142 identified publications and applied the following inclusion criteria. As we aimed for an overview of existing definitions and frameworks, articles had to offer either a definition, a model, a concept or a framework of DC. Since only a handful of the remaining publications met the criteria to be about adult and working people, we included publications about adolescents and non-working people, too.

2.1.3. Coding of articles

To get a systematic overview and analyse the remaining publications in detail ($N = 28$), we applied five categories of rating criteria (terminology used, framework proposed, publication, empirical evidence, sample). First, one of the authors of this article rated all of the publications on all of the criteria, thereby developing a detailed rating scheme including a description of the criteria and labels. Afterwards, another author rated the publications independently, following the rating scheme. The initial agreement was very high (e.g., 89.29% for terminology used). Next, discrepancies and ambiguities in the rating scores were discussed until consensus was reached and the rating scheme adjusted accordingly.

Terminology used. This criterion lists the terminology that has been used in the publication, as different terms are used to describe the concept of DC, for example, digital literacy, e-skills, and similar terminology.

Framework proposed. We define framework as any kind of model or description that aims to enhance the conceptual understanding of DC by suggesting a structure of the concept. This includes a detailed description of DC and breaking down the concept in coherent categories. A framework could include various elements on different hierarchical levels. The coding scheme differentiates between publications that propose a self-constructed framework (+) and those that did not propose any framework at all (-). Then, we differentiated further between publications that describe basic frameworks on which the ideas for their self-constructed framework about DC were based on (+) and those that proposed new, more complex frameworks with different dimensions and levels that were described in detail (++).

Publication (type, ISI-status).

Type. The publication type depends on many factors, such as the topic, the methods, and the intended audience of the research. We identified different publication types and decided on five labels: *literature review*, *policy report*, *study*, *conference paper*, and *encyclopaedia*. We labelled all the publications *literature review* that offered a discussion on relevant literature without data collection. Publications that we labelled *study* include a data collection process and describe empirical evidence. Publications labelled *policy reports* were published by political organisations. All publications that

were published at conferences were labelled *conference papers*. We used the label *encyclopaedia* for entries in a reference work or compendium that provides knowledge summaries from the research field. Furthermore, we added the name of the project that the publication was based on in brackets behind the label if this information was available.

ISI-status. The International Scientific Indexing (ISI) provides indexing of international scientific journals and conference proceedings and can be seen as one common quality criterion for the application of scientific standards. We ranked the publications in journals that are indexed with “+” and other publications with “-”.

Empirical evidence (quantitative, qualitative).

Qualitative. Qualitative research methods are used to analyse non-numerical data that have been collected from participants during an empirical data collection process (e.g. interview answers) and are embedded in the research process, which refers to the description, meaning and clarification of concepts or definitions (Field, 2012). We differentiated between publications that present any kind of empirical qualitative research on definition, framework, or conceptual clarification of DC (+) and those that did not present any kind of non-numerical data (-).

Quantitative. Quantitative research is the systematic empirical analysis of observable phenomena in form of numerical data by using statistical methods (Field, 2012), for example, data collected in structured interviews using psychophysiological methods or questionnaires. We differentiated between publications that presented any kind of numerical data and empirical quantitative research methods on the definition or conceptual clarification of DC (+) and those that did not (-).

Publications that lacked a description of the methods in so far as the rating for qualitative and quantitative was impossible to assign, were labelled as *not available (n.a.)*. The publications that are neither labelled as qualitative nor as quantitative (“-“ on both criteria) are theoretical publications.

Sample (adults, workers).

Adults. As we focus on DC at work, we were mainly interested in research about the DC of adults. This rating criterion differentiates between publications that report about a sample that includes adults (+) or children only (-).

Workers. In our definition of workers, we include employees and self-employed workers at any kind of workplace. In Table 1, we differentiated between publications that include workers in a sample (+) and those that do not (-).

Publications that did not report about data collection with a sample at all are labelled "†". If the publication lacked a comprehensible description of the sample, it was labelled "*n.a.*".

2.2. Results

Table 1 provides a comprehensible overview of the results of the rating process of the 28 identified publications.

Terminology used. *Digital competence* was the most frequently used term ($n = 20$), followed by *digital literacy* ($n = 5$). However, the different terminologies in Table 1 are just examples for the wide variety of terms that are being used to describe the concept of DC in the literature. For instance, Martin (2005) defined *digital literacy* as "the awareness, attitude and ability of individuals to appropriately use digital tools and facilities to identify, access, manage, integrate, evaluate, analyse and synthesize digital resources, construct new knowledge, create media expressions, and communicate with others, in the context of specific life situations, to enable constructive social action; and to reflect upon this process" (p. 155). Calvani, Cartelli, Fini, and Ranieri (2008) proposed a very similar definition but used the term *digital competence*. Yet not only the terminology varies but also the definitions used to explain DC. Ferrari (2012) defines DC in a very broad sense in many different aspects of life today's digital society as "the confident, critical and creative use of ICT to achieve goals related to work, employability, learning, leisure, inclusion and/or participation in society" (p. 3). With this definition, she aims to refer to many different aspects of life in today's digital society. In contrast, Sjøby (2013) defines DC as a set of skills, including basic skills such as reading and maths, and advanced ICT skills, like evaluating information and sources. This approach indicates a very general use of the term skills and DC to be a complex concept. According to Ala-Mutka (2011), DC includes knowledge, skills and attitudes, referring to Gilster (1997) who first introduced the concept. In this concept, DC does not only include basic skills such as searching for information online, but also more complex abilities, like the analysis, interpretation, and application of the information in relevant life

contexts. Torres-Coronas and Vidal-Blasco (2011) define DC as the “ability to understand and express by making analytical, productive and creative use of the information technologies and social software to transform information into knowledge” (p. 62). According to this definition, students need DC for informed decision-making and collaborative learning with the help of digital tools, for example. Furthermore, not only the terminology of the construct but also the terminology of the different hierarchical levels within the different frameworks is very diverse. What we call *dimensions* as constituting parts of DC on a medium-sized abstraction level, are called, for example, “main areas” (Ala-Mutka, 2011, p. 5) or “types” (Torres-Coronas & Vidal-Blasco, 2011, p. 63).

Framework proposed. Only in four of the publications a new framework of DC was introduced, while in 14 publications adapted version of existing frameworks were used. Eight of the publications were based on the DigComp framework (a project aimed to develop and understand the concept of DC for European citizens). Many differences in the proposed frameworks were visible, such as the number of dimensions (three to twenty-one), hierarchical levels, and level of detail in descriptions. For example, van Laar and colleagues (2017) proposed a framework that comprises seven core skills and five conceptual skills, while Torres-Coronas and Vidal-Blasco (2011) propose a framework with three different types of competencies and various levels of mastery within each competency.

Publication (type, ISI-status).

Type. Most of the included publications were rated as *article* ($n = 9$), *literature review* ($n = 8$), or *policy report* ($n = 7$). Even though we decided to narrow down the number of labels for publication type to cluster the results, there is a diversity in styles within these labels. For example, *articles* included very different types of research and different levels of quality. While some authors of *literature reviews* are merely describing and comparing existing frameworks, others propose new frameworks. Furthermore, the backgrounds of the researchers publishing about definitions and frameworks of DC (ranging from library science to educational technology) are as diverse as their purposes. The variety of publication types in DC research represents the many different methods, research disciplines, aims, and intended audiences in this area. Eighteen of the analysed publications underwent a peer-review process, while it remained unclear for ten publications if there was a peer-

reviewing process before publishing. Three of the peer-reviewed publications were published as conferences contributions.

ISI-status. Ten of the peer-reviewed publications were published in indexed journals or proceedings with an ISI-status. Three of these publications were indexed, but without a Journal Impact Factor (JIF, Clarivate Analytics, 11.02.2018). Just seven of the analysed publications met the most stringent requirements and were published in peer-reviewed journals with a JIF.

Empirical evidence (qualitative, quantitative). In just over half of the publications ($n = 16$), the authors reported clear qualitative and/or quantitative empirical evidence. The authors of eleven publications did not report about the collection of empirical evidence at all. Ten of these publications were of theoretical nature. For the policy report of Carretero, Vuorikari, and Punie (2017), it remained unclear if the authors collected empirical data. Janssen and colleagues (2013), and Ng (2012) used a mixed methods approach, reporting about the analysis of both qualitative and quantitative data.

Qualitative. In seven publications, the authors reported collecting and analysing qualitative data. The authors described the collection of qualitative data in a wide variety of approaches, for example in form of expert discussions or stakeholder consultation. Many of the publications lacked a detailed description of the research process including methods, instruments, and analyses (for a checklist, e.g. Desrosiers et al., 2007).

Quantitative. In eleven publications, the authors reported about collecting and analysing quantitative data, mostly using self-report questionnaires. Guzmán-Simón and colleagues (2016), for example, asked university students to complete online self-report questionnaires with a six-point Likert scale about DC and academic literacy.

Sample (adults, workers). In the further evaluation of this criterion, we included solely publications that provided some sort of empirical evidence and details about the sample, which we labelled with “+” in at least one subcategory of *empirical evidence*.

Adults. From these sixteen publications with data from a sample, less than half of the publications ($n = 7$) reported results on adults. Even if adults were included in the sample, in most of these publications younger participants were assessed, too ($n = 4$). For instance, Soldatova and Rasskazova (2014) interviewed adolescents and their parents, whereas Eshet-Alkalai (2004) asked ten

university students and ten adults over the age of 30. Only in three publications, the authors reported results on adult samples (inferred from the fact that participants were described as researchers and experts). However, we differentiated between the intended target group and the sample of the research. We define the sample as those participants that contributed qualitative or quantitative data. For instance, even though the samples in the research of Janssen and colleagues (2013) and of Mengual-Andrés, Roig-Vila, and Mira (2016) consisted of adults only, adults were not the main intended target group.

Workers. When looking at the seven publications that collected data from adults, even fewer publications report about the workforce as a target group ($n = 4$). For instance, the sample from Soldatova and Rasskazova includes pupils along with 1209 parents, probably partly composed of workers. Nevertheless, the workforce was not an intended target group of their study. At least eleven of the publications focus on DC in an educational context. While Janssen and colleagues (2013) asked a panel of experts with various backgrounds on DC of people of all ages, Mengual-Andrés and colleagues (2016) asked 27 university researchers on DC of students in higher education. These examples illustrate that even though the sample is (partly) composed of workers, the intended target group includes or consists entirely of non-working people.

2.3. Discussion

In a first step, we aimed to provide a comprehensive overview of existing definitions and frameworks. Reviewing the literature on DC and their potential applications for the workplace, the following conclusions can be drawn. It is apparent that many different labels for the concept of DC are prevalent, leading Ferrari and colleagues (2012) to call this field a “jargon jungle” (p. 11). Oftentimes, different terminology is used interchangeably, as synonyms, describing the same concept, but definitions and intended meanings are rather imprecise and depend on the context of use.

The frameworks and concepts proposed in the literature to describe DC differ considerably in content and scope. Most of the frameworks vary tremendously in the number of dimensions and basic assumptions of DC, for example. The high sheer number of different frameworks in Table 1 shows that in the literature there is not only disagreement on the terminology for the same construct, but also

on the structure of the concept behind the same term. Moreover, some articles propose overarching definitions of DC and therefore lack the precision and level of detail that is needed to provide an applicable definition of DC at work.

Additionally, the publication types of DC are very diverse. The authors stem from different backgrounds, pursue different purposes and the research aims at diverse audiences. This is represented by the many different publication types that were used to write about DC (e.g., policy reports, peer-reviewed journal articles, popular scientific articles). As we are interested in DC at work from a scientific perspective, we focussed on scientific peer-reviewed articles that were published in journals with ISI-Status. However, this publication type is not sufficiently represented in the literature about DC, so far. The result of the analysis supports the aim of this article to follow the call for more scientific research on DC that meet the highest standards. Especially IO psychologists mostly have neglected DC as a topic so far, even though they have a lot to contribute to this research field.

In terms of empirical evidence, in most of the publications the documentation of the data collection, instruments used, and data analysis was insufficient. Limitations of the publications with empirical evidence encompass the sample, instruments, and analysing methods, among others. Finally, adults and more specifically workers have rarely been included in samples and even if so, they were asked as experts about DC of another target group and not about their own DC. In particular, the insight view of practitioners about DC has been neglected so far, despite the fact that practitioners apply DC at work on a daily basis. Furthermore, a link between the theoretical research and applications in the work context is greatly missing, even though the gap between needed and actual DC of the workforce has been recognised as an important issue. Therefore, we focus on working adults and include the perspective of practitioners in the development of a framework of DC in the next section of this article.

In sum, we conclude that more scientific methods and rigorous scientific practice are needed to address DC at work. At this stage of research, on the basis of this literature review, it seems reasonable to combine different methods and include various relevant perspectives to shed light on the construct and encourage a focus on the application of DC at work.

3. Development of a definition and relevant dimensions of DC at work

In this section, we aim to address the science-practice gap with regard to DC by combining qualitative and quantitative research methods and integrating the view of different stakeholders. First, we lay ground for a common understanding of DC at work among researchers, practitioners, and politicians by proposing a comprehensible definition of DC at work. Second, we develop a framework that includes a conclusive description of relevant dimensions of DC at work, which does not only refer to a theoretically well-conceived basis but also allows applications in practice. For this, we combine the results of the previous literature review with the insight knowledge of practitioners who experience digitalisation processes at work first-hand.

3.1. Proposed definition of digital competencies at work

So far, there is no agreed-upon definition of DC neither any definition to express a common understanding of DC at work. Based on our literature review, and in particular on existing definitions of the more general concept of competencies at work (Guzmán-Simón, 2017; Kauffeld & Paulsen, 2018) and the respective central characteristics in terms of knowledge, skills, abilities and other characteristics (KSAOs, e.g. Aamodt, 2009; Krumm, Mertin, & Dries, 2012), we propose a working definition of DC at work as follows:

Digital competencies at work are a set of basic knowledge, skills, abilities, and other characteristics that enable people at work to efficiently and successfully accomplish their job tasks regarding digital media at work.

We chose to adopt the term *digital competencies* from the many diverse terms used in the literature for several reasons. We chose the term *digital*, because it is a relatively broad term that includes any kind of ICT and digital media, referring to devices and applications that are used at work, now and in the future.

By choosing the term *competencies* over any other terminology (e.g., literacy), we want to stress that we are building on competencies as a well-established construct in IO research. Building on

definitions of competencies, the plural was chosen to highlight that competencies are generally not unidimensional but composed of different dimensions. According to the KSAO concept, which is often used interchangeably with the concept of competencies at work (Aamodt, 2009; Krumm et al., 2012), workers need knowledge (K), skills (S), abilities (A), and other characteristics (O) to effectively and successfully perform at their job (Campion et al., 2011; Spector, 2008). *Knowledge* is described as the information a worker needs to perform a job task. While *skills* are defined as the “proficiency to perform a particular task” (Aamodt, 2009, p. 53) that is learnable, *abilities* are defined as a “basic capacity for performing a wide range of different tasks, acquiring knowledge, or developing a skill” (Aamodt, 2009, p. 53) that can only be trained to a certain degree (Campion et al., 2011; Krumm et al., 2012). Finally, *other characteristics* refer to personality characteristics, motivation, personal interests, prior experiences or degrees that are required for good performance at work, for example (e.g., Krumm et al., 2012; Spencer & Spencer, 1993). Especially in the work context, a work task usually requires different types of competencies to be mastered successfully (Kauffeld & Paulsen, 2018; Spencer & Spencer, 1993). Each worker has an individual set of competencies and each job position requires a combination of different competencies based on the KSAO concept or its variations. Several different competencies of workers, teams, or organisations have been shown to predict important observable results and are requirements for good performance at work (Spencer & Spencer, 1993).

Among the various expressions used, we adopted the term *digital media* as it is thought to include different digital devices and applications that are used on a regular basis to master typical office tasks at work, for example, mail programmes.

Finally, we focussed on DC *at work* in the definition proposed as this is a life domain, where people cannot decide for themselves if they want to use DC, as they may in their leisure time. Not least because of that, people can benefit the most from their DC at work, where it is important to save resources, act efficiently and fast. We assumed that a majority of the workers at typical office workplaces spent most of the working time using a digital device, nowadays (Arnold et al., 2015; Gallardo-Echenique et al., 2015). Moreover, while teams and organisations can also be digitally competent, we focussed on DC from the perspective of an individual worker in the workforce. Other

perspectives, like the organisational or societal ones, are discussed insofar as they contribute to the concept of DC of the workforce.

3.2. Dimensions of digital competencies at work: Integrating the literature and practitioners view

Even though several concepts of DC have been proposed so far (see Table 1; e.g., Carretero et al., 2017; Eshet-Alkalai, 2004), none of them builds on all of the facets of the KSAO approach. Furthermore, research about DC at work is still scarce (Ala-Mutka, 2011; Murawski & Bick, 2016). Therefore, we base our understanding of DC at work on knowledge, skills, abilities, and other characteristics. To specify relevant dimensions for the workplace, we narrowed down the target group of DC to white-collar workers with office jobs who spend most of their time at work with digital devices but do not have digital media as the main content of their work tasks (e.g., like IT specialists).

3.2.1. Method

The extensive review of the literature about DC in Chapter 2 was complemented by interviews with practitioners about the definition of DC at work. From both perspectives, descriptions and elements of DC were collected and clustered, with the aim to develop a comprehensive taxonomy and dimensions of relevant factors of DC at work.

Participants and Procedure. We extracted content-related descriptive units about the definition and concept of DC from the literature, based on the previously reported literature review, using methods of the inductive content analysis (Elo & Kyngäs, 2008; Mayring, 2014). The units were chosen to be as small as possible while still adding value in terms of meaningful content. Therefore, the length of the units varied between one word (e.g., communication) and full sentences (e.g., the ability to make informed judgements about what is found online, which he equates to ‘the art of critical thinking’). Then, each of the authors clustered the extracted content-related units of DC from the literature by similarity. The separately obtained results were compared and discrepancies solved by discussion until consensus was reached. For each cluster, a heading was agreed upon.

Subsequently, we included the view of practitioners about the definition and concept of DC at work. For this end, we developed a half-structured interview guideline based on the critical incidents

technique (Flanagan, 1954). Eleven graduate students with prior knowledge about definitions and concepts of DC used these interview guidelines to interview practitioners with diverse expertise in digitalisation processes within the context of work about their definitions of DC at work. To cover a broad range of DC in many diverse work settings of white-collar workers, we attached importance to the heterogeneity of the sample, particularly with regard to the educational background, hierarchical level, job position, and the branch of the practitioners. The hierarchical level of the practitioners varied between general manager ($n = 1$), upper management ($n = 1$), middle management ($n = 2$), lower management ($n = 2$) and employee without managerial functions ($n = 5$). The job positions of the practitioners were as diverse as HRM ($n = 4$), research and development ($n = 2$), IT ($n = 2$), company management ($n = 2$) and marketing ($n = 1$). Also, the branches of their companies were a heterogeneous mix of industry ($n = 5$), finance ($n = 2$), tourism ($n = 11$), marketing ($n = 1$), and other branches ($n = 2$). Additionally, we chose a mixed sample in terms of age and gender to prevent any biases based on these factors.

The first part of the interview consisted of demographic questions (e.g., What is your job position?), the second part was about the definition of DC (e.g., Asking in a general way: What do you understand by DC?) and in the third part, we asked the practitioners about basic and specific DC at work. Except for the first three questions, we used an open-answer format. We aimed to make the practitioners look at DC from various angles to cover a broad range of behaviours. To generate more diverse answers, we asked the practitioners to change their perspectives and describe their supervisors and subordinates perspective on which DC are needed at work, too (e.g., Which DC are needed at most workplaces, in your opinion?).

Parallel to the process of extracting and sorting descriptions from the literature, the graduate students extracted content-related descriptive units about the definition and concept of DC at work from the interviews with the practitioners and sorted these units by similarity. The graduate students chose a heading for each cluster, too.

To combine the insights from the scientific literature with those from the practitioners at work, we combined the two sets of clusters from the scientific literature and the interviews to formulate dimensions of DC at work with a heading and anchor samples for each dimension. However, it was

not the aim to define a model with distinct categories. Instead, we intended to formulate a comprehensive and encompassing definition of DC that considers the vast variety of different aspects, aiming at a medium-sized abstraction level.

Finally, we invited five researchers from the field of social sciences with prior knowledge of competencies and digitalisation processes to validate the dimensions. We asked them to assign units from the literature and the interviews to the headings we chose for the dimensions. We compared the results with our first allocation of the units to the headings and the dimensions adjusted if necessary.

3.2.2. Results

The clustering process resulted in 25 dimensions of DC at work. In total, 946 content-related units describing DC were extracted. From the literature, we extracted 265 units. The clustering and subsequent discussion of the clusters resulted in twelve clusters of DC from the literature. From the interviews, the graduate students extracted 681 units and clustered these units into fifteen clusters (with 30 facets). Merging the clusters from the literature with those from the interviews resulted in 25 dimensions of DC at work. Table 2 depicts a summary of the results of the clustering process.

The content of the clusters from the literature and from practice showed a huge overlap. First, we matched the clusters from the literature and interviews that included the same or very similar wording in the headings (e.g., security, communication) to form one dimension. Afterwards, we scanned the remaining clusters for similar keywords in the description and examples, marking similar intended meanings (e.g., data management and organisation of digital information), and matched those clusters to form one dimension. Nevertheless, the input from the practitioners resulted in nine clusters that were not found in the literature (e.g., *Networking*), while six of the clusters were not mentioned in the interviews but found in the literature (e.g., *Creating content: Creative, innovative*). Finally, we formed dimensions of these remaining clusters with input, either from the literature (e.g., *Ethics and moral*) or the interviews (e.g., *Sharing data with others*), too.

In the following, the 25 interrelated dimensions are outlined shortly (see detailed descriptions in the supplementary material).

Handling of hardware is the competency to appropriately deal with hardware at work. *Handling of software* is the competency to use at least basic software that is relevant for one's work. At office workplaces, these are typically mail and text programmes as general applications and more specific programmes depending on the workplace. *Programming* is the competency to use at least one programming language to customise work-relevant programmes, create digital content or maintain systems. *Handling of applications* is the competency to know which application and which medium is suitable for which task and have the skills to deal with it. *Innovative capability and creativity* is the competency to get creative and promote digital innovation to fix problems and increase efficiency. *Information processing: Recognizing one's own knowledge gaps* is the competency to recognize what one does not know or cannot do on one's own with digital media. *Information processing: Search* is the competency to perform an efficient digital information search at work independently. This includes knowing where to find the required information, working with databases and online search engines, and selecting suitable search results. *Information processing: Data analysis* is the competency to systematically analyse and interpret digital data and information. *Information processing: Evaluating* is the competence to critically scrutinise and weigh up digital information by assessing quality, appropriateness and credibility. *Data organisation* is the competency to archive and organise digital data in a useful, structured manner. *Effective usage* combines the basic knowledge, skills, motivation and creative abilities to recognise and use the potential of digital media and applications to increase efficiency in the workplace. *Communication* is the competency to use appropriate digital communication channels to communicate with others at work. *Collaboration* is the competency to use digital media for business collaboration, for example with business partners and customers. *Networking* is the competency of being well-connected in one's business environment with the help of digital media. It is getting in touch with relevant people inside and outside one's company through digital networks to discuss topics and get help. *Netiquette* is the awareness that there are certain rules of digital communication and the competency to comply with them by behaving in the appropriate social manners in work-related digital exchanges. *Sharing data with others* is the competency to share data, for example, to work synchronously by using digital media and to be willing to work online with others. *Cultural aspects* are the competency to participate in digital intercultural communication, to

accept it and to appreciate diversity in a digital context. *Security and law* is the competency to respect existing laws in a digital context (e.g., copyright) and to adequately protect work-related private and corporate data from disclosure. *Responsibility* is the competency to consider the consequences of one's actions in online contexts and to act responsibly in dealing with each other, and with private and corporate data (e.g., visibility of information to others). It also includes a reflective attitude to the influences of digital media and a sensitive attitude towards possible problems with the medium used. *Goals and motivation* is the competency to have the patience to try new digital applications, pursuing one's goals perseveringly and making an effort. It also includes the motivation to use digital media at work and showing endurance when dealing with digital devices and applications. *Willingness to learn and openness* is the competency to be willing to learn new things about digital media and applications and to be open to change the workplace through digitalisation. *Ethics and moral* is the competency to behave online in accordance with ethical and moral convictions and to observe them in daily work. *Autonomy and independence* is the competency to be able to make meaningful and profitable use of the flexible framework conditions through digitalisation at work. *Problem-solving* is the competency to develop possible solutions to a problem, try it out and apply the best solution while identifying the core of the problem and preventing it from occurring again. *Train others* is the competency to communicate one's knowledge and thus to strengthen others in their DC.

Our validation approach of these 25 dimensions supports the chosen structure. The content of the units from the literature review and the interviews were very similar in each of the dimensions *Communication*, *Collaboration*, *Information processing: Search*, and *Willingness to learn and openness*. Out of the 946 total extracted units, 774 units were assigned to one dimension unambiguously (e.g., "being able to work with MS Office" was assigned to the dimensions *Handling of software*). Especially the assignment of units to *Cultural aspects* was very clear as none of the units assigned to these dimensions was assigned to another dimension. Fifty-five units were assigned to two different dimensions (e.g., "being able to work together with others using one drive" was assigned to *Collaboration* and *Sharing data with others*). The remaining units were assigned to more than two different dimensions (e.g., "being able to use the internet responsibly for communicating, socializing

and learning” was assigned to *Effective usage, Netiquette, Security and law, and Responsibility*). Overall, most of the units were assigned to *Handling of software* (105 first assignments, 9 second assignments), and least units were assigned to *Cultural aspects* (8 first assignments). Many of the units assigned to *Communication* were also assigned to one or more of the dimensions *Collaboration, Networking, or Netiquette* (e.g., “choose the best media for the target group”).

3.3. Discussion

Following the call for clarification of the concept of DC at work, we proposed a definition and framework, based on concepts of competencies encompassing KSAOs to be applied by researchers, practitioners, and politicians.

While prior research greatly neglected the work context or solely focused on workers from the educational sector (Aesaert, van Nijlen, Vanderlinde, & van Braak, 2014; Brevik, Gudmundsdottir, Lund, & Strømme, 2019), we managed to integrate two different perspectives by combining the findings of the literature review with the ideas of practitioners. We identified 25 dimensions of DC at work that seem to be important in theory and practice. Besides the vast similar content from the literature and the interviews, which confirms the importance of those dimensions at work, each perspective added unique content, too. While the dimensions that are based on a cluster from the literature only (e.g., *Ethics and moral*) represent considerations on a meta-level; other dimensions that are based on a cluster from the practice only (e.g., *Handling of hardware*) represent competencies that are important to accomplish daily tasks at work. This results at least partly from the focus on daily tasks that we chose on purpose for the interview questions. The consideration of both perspectives – a global meta-level and detailed micro-level – is necessary to capture all DC possibly needed at work.

The results of this research indicate that the dimensions of DC at work are composed of a specific combination of knowledge, skills, abilities, and other characteristics that are needed to perform at today’s digital workplaces. Hence, our suggested framework of DC at work is in line with the concept of KSAOs. For instance, *Handling of Hardware* requires basic knowledge about the devices and hardware at hand, and the physical and cognitive ability to operate them. Additionally, the skills to handle the hardware appropriately and the motivation to do so are basic requirements for this

competency. However, a clear allocation of the dimensions of DC at work to the KSAO facets is not sensible. Not all of the dimensions include all of the KSAO components. Instead, the importance of the KSAO components varies between the dimensions. For example, while *Information processing: Recognizing one's own knowledge gaps* is based on the knowledge facet mainly, *Goals and motivation* is mainly based on other characteristics, like motivation. Otherwise, *Problem-solving* and *Train others* are dimensions of DC at work that integrate all of the KSAO facets.

Although we obtained a comprehensive list of relevant dimensions of DC by our approach, some of the dimensions we obtained still include greatly overlapping content and cannot be defined distinctly (e.g., *Communication*, *Collaboration*). However, our aim was not to find distinctive dimensions but to outline as many different aspects of the concept of DC at work as possible to contribute to the concept clarification. Thus, a greater number of dimensions illustrates that the emphasis is on the vast variety of DC at work. With our findings, we hope to lay ground for future discussion and research on the dimensionality of the construct. Therefore, future research is urged to empirically test for similarities and differences of DC for different workplaces.

Building upon our results and in line with prior research (Markus, Cooper-Thomas, & Allpress, 2005), we suggest that DC at work can be divided into basic and specific DC. Basic DC are needed at most office workplaces to accomplish everyday tasks. Examples are writing e-mails, using text processing programmes or conducting internet research. Additionally, there are DC that are specific for a workplace, occupational training, or a company, for example, and they are needed by some workers in special positions for specific tasks only (e.g., using in-house software programmes or communicating results of a workgroup). Following this approach implies that the required DC of an individual worker also depend on many external factors such as the structure and size of the company or the specific work tasks. For instance, DC in cultural aspects are very important in global companies with an international background. However, employees in local companies do not necessarily need this competency to accomplish their daily work tasks. There is probably no job position that requires the maximum of all 25 dimensions of DC at work, but each job position requires a unique set of basic and specific DC at work.

4. Conclusion and implications

4.1. Conclusions

Our research provides important insights into the construct of DC at work by providing an overview of existing definitions and frameworks. A thorough analysis of the available literature revealed a lack of scientific research on DC of adults and a neglect of the work context. However, the large variety of terms and proposed frameworks shows the interest in DC in many different contexts such as education, politics, or media and communication. While acknowledging the important contributions that these publications can make, we addressed the science-practice gap by integrating different perspectives in our research. Therefore, in addition to the systematic literature review, we conducted eleven half-structured interviews with practitioners from the work context. After analysing the results, we were able to identify and validate 25 dimensions of DC for workers that are not only based on the literature but also on insights of practitioners. The involvement of many diverse groups of people with different background knowledge and multiple opportunities to discuss the findings during the analysis supports the objectivity of these dimensions. The findings indicate that even though there are similarities in the definitions of DC between practitioners and researchers, there were also notable differences, whereas each perspective added unique content to the framework. For example, practitioners focus more on the details and the application of the concept at work, while researchers highlight the importance of aspects on a more general level. Furthermore, our results suggest that the concept of DC is multi-faceted and can be based on knowledge, skills, abilities, and other characteristics. With our research, we hope to broaden and clarify the scope of the concept of DC and encourage further research that adds to the understanding of the concept of DC with a focus on adults at work.

Furthermore, our findings contribute to the research field by putting the prior neglected work context in the focus of research about DC. In comparison to the existing literature (e.g., Janssen et al., 2013), we provide an updated review of the literature on DC, and combine different methods and approaches, thereby not only focussing on the DC of teachers and students, but on white-collar workers (e.g., Aesaert et al., 2014; Brevik et al., 2019). Moreover, our framework is based on validated models about competencies from industrial and organisational psychology. Nevertheless, we

enhance the applicability of the findings in the work context by integrating different perspectives from research and practice. Furthermore, we managed to provide a holistic view of the concept that encompasses detailed descriptions of the 25 dimensions of DC at work.

4.2. *Limitations of the study and implications for future work*

Although this research represents a systematic effort to consider different perspectives and combine various research methods, there are methodological and content-related limitations. For instance, our results do not generalise to the whole workforce and all workplaces as we focused on a specific group of the working population (white-collar workers) when developing relevant dimensions of DC. Even though we purposefully chose a broad range of practitioners with different educational backgrounds and job positions, all of them are knowledge workers with office jobs (located in the south of Germany). These restrictions of the target group are needed to conduct a detailed analysis of DC at specific workplaces leading to specific and applicable results. For instance, by narrowing down the target group to white-collar workers we obtain a framework that is specific enough to meet the requirements for a job demands analysis. However, therefore we do not know yet which dimensions of our suggested framework might generalize to other working populations.

Additionally, we do not know yet how exactly the different suggested dimensions of the framework are interrelated. Future empirical research needs to address this question to reveal the underlying factor structure of DC at work. Merging similar dimensions, for example, according to the results of factor analysis could improve the structure of the framework of DC at work. For example, it appears plausible that the dimensions that refer to interpersonal behaviour (e.g., *Communication*, *Collaboration*, *Sharing data with others*, and *Networking*) show more overlapping content than other dimensions (e.g., *Handling of hardware*, *Security and law*) and therefore might form an aggregated factor. Also, dimensions like *Problem-solving* or *Willingness to learn and openness*, seem to affect many other dimensions and might, therefore, be on another level in a competency hierarchy. However, while there is face validity to merge dimensions to aggregated factors, a larger number of dimensions has the advantage of highlighting different aspects of DC, which was a goal of this research. Moreover, future research is encouraged to investigate the nomological network of the competencies

we found, for example, by separating them from other competencies needed at work or more general concepts like motivation, knowledge or personality factors.

Finally, a limitation of this research revolves around the fast-changing nature of the subject itself. DC are linked to the fast-paced technological progress very closely as they evolve with the implementation of new tools and applications that change the way we work. Therefore, the timeliness of the research results and the flexibility of frameworks are crucial to keep them applicable in changing workplaces (Ala-Mutka, 2011; Bawden, 2008). Dynamic frameworks of DC at work that consider future-oriented job requirements are needed. Hence, the DC that are needed in the future world of work can be more or less imprecise given that they are based on predictions. Nevertheless, to prepare the workforce for the demands of their work in the future, the DC that are needed in the long run have to be trained now.

4.3. Applications and utility

The findings of this research imply several theoretical and practical applications. First, we provide the field with a definition and a framework of DC at work. By combining multiple perspectives, stemming from literature about DC and insights of practitioners, we foster the common understanding, broaden the scope of the concept and lay ground for applications in practice. We drew particular attention on the specifics of the work context, which is a major field of application for this topic.

Practitioners may use our framework of DC to identify the DC needed at specific workplaces. For instance, HR managers may use our framework to identify the requirements of a job or developmental potential in the current and future workforce. Adding specifically relevant DC for each job profile on basis of our framework could enhance needs analyses in personnel recruiting by providing a more realistic view of the current level of DC of the workforce (Caldwell & O'Reilly, 1990). Knowing the specific DC that job applicants need at the workplace they are applying for could enhance the curricula of talent management programmes, for example, and lead to the development and implementation of more effective and efficient customized training (Chen & Naquin, 2006). Based on our findings, future research could develop specific models of DC that are adjusted to the

requirements of specific workplaces. For these specific models, for example, the job profile, the prior knowledge and education of the workers could be taken into account. However, the effectiveness of possible applications of this research in practice has yet to be evaluated.

Furthermore, we recognise the developmental potential of DC at work. Even though the coming generations are referred to as digital natives, it is wrong to assume that there would be no need to develop DC for adults in the future anymore (e.g., Li & Ranieri, 2010; Ng, 2012). The composition of DC needed at different workplaces is mostly specific. Therefore, the results of this research can be used as a basis to develop specific training for the individually needed dimensions of DC adjusted to the prior knowledge, time available, and other individual circumstances of the learner.

References

- Aamodt, M. G. (2009). *Industrial/Organizational Psychology: An applied approach* (6th ed.). London: Cengage Learning.
- Aesaert, K., van Nijlen, D., Vanderlinde, R., & van Braak, J. (2014). Direct measures of digital information processing and communication skills in primary education: Using item response theory for the development and validation of an ICT competence scale. *Computers & Education*, 76, 168–181. <http://dx.doi.org/10.1016/j.compedu.2014.03.013>.
- Ahmad, M., Karim, A. A., Din, R., & Albakri, I. S. M. A. (2013). Assessing ICT competencies among postgraduate students based on the 21st century ICT competency model. *Asian Social Science*, 9(16), 32–39. <https://doi.org/10.5539/ass.v9n16p32>.
- Ala-Mutka, K. (2011). *Mapping digital competence: Towards a conceptual understanding* (JRC 67075). Seville. Retrieved from the Joint Research Centre: Institute for Prospective Technological Studies website: <https://ec.europa.eu/jrc/en/about/jrc-site/seville>.
- Ancarani, A., & Di Mauro, C. (2018). Successful digital transformations need a focus on the individual: How does digitalization affect the behaviour of purchasers and team members in related functions? In F. Schupp & H. Wöhner (Eds.), *Digitalisierung im Einkauf* (pp. 11-26). Wiesbaden: Springer Gabler.
- Arnold, D., Butschek, S., & Steffes, S. (2016). *Digitalisierung am Arbeitsplatz: Bericht* (FB 468). Berlin. Retrieved from the Bundesanstalt für Arbeitsschutz und Arbeitsmedizin website: <https://www.bmas.de/DE/Service/Medien/Publikationen/Forschungsberichte/Forschungsbericht-Arbeitsmarkt/fb468-digitalisierung-am-arbeitsplatz.html;jsessionid=39616914B2E4FE449935BB2BAF6A6A8D>.
- Bawden, D. (2001). Information and digital literacies: A review of concepts. *Journal of Documentation*, 57(2), 218-259. <https://doi.org/10.1108/EUM0000000007083>.
- Brečko, B., & Ferrari, A. (2016). *The digital competence framework for consumers* (EUR 28133). Luxembourg. Retrieved from the Joint Research Centre for Policy Report website: https://ec.europa.eu/commission/index_en.

- Brevik, L. M., Gudmundsdottir, G. B., Lund, A., & Strømme, T. A. (2019). Transformative agency in teacher education: Fostering professional digital competence. *Teaching and Teacher Education*, 86, 102875. <https://doi.org/10.1016/j.tate.2019.07.005>.
- Caldwell, D. F., & O'Reilly III, C. A. (1990). Measuring Person-Job Fit with a profile-comparison process. *Journal of Applied Psychology*, 75(6), 648–657. <http://dx.doi.org/10.1037/0021-9010.75.6.648>.
- Calvani, A., Cartelli, A., Fini, A., & Ranieri, M. (2008). Models and instruments for assessing digital competence at school. *Journal of E-Learning and Knowledge Society*, 4(3), 183-193. Retrieved from http://je-lks.org/ojs/index.php/Je-LKS_EN/index.
- Campion, M. A., Fink, A. A., Ruggeberg, B. J., Carr, L., Phillips, G. M., & Odman, R. B. (2011). Doing competencies well: Best practices in competency modeling. *Personnel Psychology*, 64(1), 225-262. <https://doi.org/10.1111/j.1744-6570.2010.01207.x>.
- Carnevale, A. P., & Smith, N. (2013). Workplace basics: the skills employees need and employers want. *Human Resource Development International*, 16(5), 491-501. <https://doi.org/10.1080/13678868.2013.821267>.
- Carretero, S., Vuorikari, R., & Punie, Y. (2017). *DigComp 2.1: The digital competence framework for citizens with eight proficiency levels and examples of use* (EUR 28558). Luxembourg. Retrieved from Joint Research Center website: <https://ec.europa.eu/jrc/en>.
- Cartelli, A. (2010). Frameworks for digital competence assessment: Proposals, instruments and evaluation. *Proceedings of Informing Sciences & IT Education Conference (InSITE)*, 561-574. <https://doi.org/10.28945/1274>.
- Cascio, W. F., & Montealegre, R. (2016). How technology is changing work and organizations. *Annual Review of Organizational Psychology and Organizational Behavior*, 3(1), 349-375. <https://doi.org/10.1146/annurev-orgpsych-041015-062352>.
- Chen, H.-C., & Naquin, S. S. (2006). An integrative model of competency development, training design, assessment centre, and multi-rater assessment. *Advances in Developing Human Resources*, 8(2), 265-282. <https://doi.org/10.1177/1523422305286156>.

- Clarivate Analytics. (2018). *Journal citation reports*. Retrieved from <https://clarivate.com/products/journal-citation-reports/> Accessed 11 February 2018.
- Desrosiers, E. I., Sherony, K., Barros, E., Ballinger, G. A., Senol, S., & Campion, M. A. (2007). Writing Research Articles: Update on the Article Review Checklist. In S. G. Rogelberg (Ed.), *Blackwell Reference Online. Handbook of research methods in industrial and organizational psychology* (pp. 459-478). Oxford: Blackwell.
- Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of advanced nursing*, 62(1), 107–115. <https://doi.org/10.1111/j.1365-2648.2007.04569.x>.
- Eshet-Alkalai, Y. (2004). Digital literacy: A conceptual framework for survival skills in the digital era. *Journal of Educational Multimedia and Hypermedia*, 13(1), 93-106. Retrieved from <https://www.aace.org/pubs/jemh/>.
- Ferrari, A. (2012). *Digital competence in practice: An analysis of frameworks* (No. EUR 25351). Seville. Retrieved from Joint Research Centre: Institute for Prospective Technological Studies website: <http://www.jrc.ec.europa.eu>.
- Ferrari, A. (2013). *DIGCOMP: A framework for developing and understanding digital competence in Europe* (No. EUR 26035). Seville. Retrieved from the Joint Research Centre: Institute for Prospective Technological Studies website: <http://ipts.jrc.ec.europa.eu>.
- Ferrari, A., Brečko, B. N., & Punie, Y. (2014). DIGCOMP: A framework for developing and understanding digital competence in Europe. *Elearning Papers*. (38), 1-15. Retrieved from www.openeducationeuropa.eu/en/elearning_papers.
- Ferrari, A., Punie, Y., & Redecker, C. (2012). Understanding digital competence in the 21st Century: An analysis of current frameworks. In Ravenscroft A., Lindstaedt S., Kloos C.D., Hernández-Leo D. (Eds.), *21st century learning for 21st century skills*. EC-TEL 2012. *Lecture notes in computer science: Vol. 7563*. (pp. 79–92). Berlin, Heidelberg: Springer. https://doi.org/10.1007/978-3-642-33263-0_7.
- Field, A., Miles, J., & Field, Z. (2012). *Discovering statistics using R* (1st ed.). London: Sage Publication Ltd.

- Flanagan, J. C. (1954). The critical incident technique. *Psychological Bulletin*, 51(4), 327-358.
<https://doi.org/10.1037/h0061470>.
- Gallardo-Echenique, E. E., de Oliveira, J. M., Marques-Molias, L., & Esteve-Mon, F. (2015). Digital competence in the knowledge society. *MERLOT Journal of Online Learning and Teaching*, 11(1), 1-16. Retrieved from <https://www.merlot.org/merlot/index.htm>.
- Gilster, P. (1997). *Digital literacy*. New York: Wiley Computer Pub.
- Guzmán-Simón, F., García-Jiménez, E., & López-Cobo, I. (2017). Undergraduate students' perspectives on digital competence and academic literacy in a Spanish University. *Computers in Human Behavior*, 74, 196-204. <https://doi.org/10.1016/j.chb.2017.04.040>.
- Hatlevik, O. E. (2009). How to identify and understand digital literacy among 9th-grade Norwegian students: Examining the influences from school and home on students' digital literacy. *Digital Kompetanse*, 4(3-4), 159-174. Retrieved from <https://www.idunn.no/dk>.
- Hatlevik, O. E., Ottestad, G., & Throndsen, I. (2015). Predictors of digital competence in 7th grade: A multilevel analysis. *Journal of Computer Assisted Learning*, 31(3), 220-231. <https://doi.org/10.1111/jcal.12065>.
- Hobbs, R. (2010). *Digital and media literacy: A plan of action*. Washington D.C.: The Aspen Institute Communications and Society Program; Knight Foundation.
- Ilomäki, L., Kantosalo, A., & Lakkala, M. (2011). What is digital competence. *Linked Portal*, 1-11, from <http://linked.eun.org/web/guest/in-depth3>.
- Janssen, J., Stoyanov, S., Ferrari, A., Punie, Y., Pannekeet, K., & Sloep, P. (2013). Experts' views on digital competence: Commonalities and differences. *Computers & Education*, 68, 473-481. <https://doi.org/10.1016/j.compedu.2013.06.008>.
- Kauffeld, S., & Paulsen, H. F. K. (2018). *Kompetenzmanagement in Unternehmen: Kompetenzen beschreiben, messen, entwickeln und nutzen* (1st ed.). *Arbeits-, Organisations- und Wirtschaftspsychologie*. Stuttgart: Verlag W. Kohlhammer.
- Krumm, S., Mertin, I., & Dries, C. (2012). *Kompetenzmodelle: Praxis der Personalpsychologie*. *Praxis der Personalpsychologie: Vol. 27*. Göttingen: Hogrefe.

- Li, Y., & Ranieri, M. (2010). Are 'digital natives' really digitally competent? – A study on Chinese teenagers. *British Journal of Educational Technology*, 41(6), 1029-1042. <https://doi.org/10.1111/j.1467-8535.2009.01053.x>.
- Maderick, J. A., Zhang, S., Hartley, K., & Marchand, G. (2016). Preservice teachers and self-assessing digital competence. *Journal of Educational Computing Research*, 54(3), 326-351. <https://doi.org/10.1177/0735633115620432>.
- Markus, L. H., Cooper-Thomas, H. D., & Allpress, K. N. (2005). Confounded by competencies? An evaluation of the evolution and use of competency models. *New Zealand Journal of Psychology*, 34(2), 117–126. Retrieved from <https://www.psychology.org.nz/.../new-zealand-journal-of-psychology>.
- Martin, A., & Grudziecki, J. (2006). DigEuLit: Concepts and tools for digital literacy development. *Innovation in Teaching and Learning in Information and Computer Sciences*, 5(4), 249-267. <https://doi.org/10.11120/ital.2006.05040249>.
- Mayring, P. (2014): Qualitative content analysis. Theoretical foundation, basic procedures and software solution. Retrieved from <http://nbn-resolving.de/urn:nbn:de:0168-ssolar-395173>.
- Mengual-Andrés, S., Roig-Vila, R., & Mira, J. B. (2016). Delphi study for the design and validation of a questionnaire about digital competences in higher education. *International Journal of Educational Technology in Higher Education*, 13(1), 55. <https://doi.org/10.1186/s41239-016-0009-y>.
- Meyers, E. M., Erickson, I., & Small, R. V. (2013). Digital literacy and informal learning environments: An introduction. *Learning, Media and Technology*, 38(4), 355-367. <https://doi.org/10.1080/17439884.2013.783597>.
- Murawski, M., & Bick, M. (2017). Digital competences of the workforce – a research topic? *Business Process Management Journal*, 23(3), 721-734. <https://doi.org/10.1108/BPMJ-06-2016-0126>
- Ng, W. (2012). Can we teach digital natives digital literacy? *Computers & Education*, 59(3), 1065-1078. <https://doi.org/10.1016/j.compedu.2012.04.016>.

- Shippmann, J. S., Ash, R. A., Batjtsta, M., Carr, L., Eyde, L. D., Hesketh, B., Kehoe, J., Pearlman, K., Prien, E.P., & Sanchez, J. I. (2000). The practice of competency modeling. *Personnel Psychology*, 53(3), 703–740. <https://doi.org/10.1111/j.1744-6570.2000.tb00220.x>.
- Siiman, L.A., Mäeots, M., Pedaste, M., Simons, R.-J., Leijen, Ä., Rannikmäe, M., Võsu, K., & Timm, M. (2016). An instrument for measuring students' perceived digital competence according to the DIGCOMP framework. In P. Zaphiris & A. Ioannou (Eds.), *Learning and Collaboration Technologies* (pp. 233-244). Cham: Springer International Publishing. <https://doi.org/10.1007/978-3-319-39483-1>.
- Søby, M. (2013). Learning to be: Developing and understanding digital competence. *The Norwegian context*, 8(3), 134–138. Retrieved from <https://www.idunn.no/dk>.
- Soldatova, G. V., & Rasskazova, E. I. (2014). Assessment of the digital competence in Russian adolescents and parents: Digital Competence Index. *Psychology in Russia: State of the Art*, 7(4), 65-74. <https://doi.org/10.11621/pir.2014.0406>.
- Spector, P. E. (2008). *Industrial and organizational psychology: Research and practice* (5th ed.). Hoboken: John Wiley & Sons.
- Spencer, Lyle, M., Jr. & Spencer, Signe, M. (1993). *Competence at work: Models for superior performance*. New York: John Wiley & Sons.
- Torres-Coronas, T., & Vidal-Blasco, M. A. (2011). Adapting a face-to-face competence framework for digital competence assessment. *International Journal of Information and Communication Technology Education*, 7(1), 60–69. <https://doi.org/10.4018/jicte.2011010106>.
- Van Laar, E., van Deursen, A.J.A.M., van Dijk, J.A.G.M., & de Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. *Computers in Human Behavior*, 72, 577-588. <https://doi.org/10.1016/j.chb.2017.03.010>.
- Vieru, D. (2015). Towards a multi-dimensional model of digital competence in small- and medium-sized enterprises. In D.B.A.M. Khosrow-Pour (Ed.), *Encyclopedia of Information Science and Technology, Third Edition* (pp. 6715-6725). IGI Global. <https://doi.org/10.4018/978-1-4666-5888-2.ch660>.

Zaphiris, P., & Ioannou, A. (2016). *Learning and Collaboration Technologies* (Vol. 9753). Cham: Springer International Publishing.

APPENDIX

Table 1

Overview of the publications and rating criteria included in the systematic literature review and results of the rating process.

Author(s)	Terminology used	Framework proposed	Publication		Empirical Evidence		Sample	
			Type	ISI-Status ^a	Qualitative	Quantitative	Adults	Workers
Ala-Mutka (2011)	Digital Competence	+	Policy Report (DigComp*)	-	+	-	n.a.	n.a.
Bawden (2001)	Digital Literacies	-	Literature Review	+	-	-	†	†
Brečko & Ferrari (2016)	Digital Competence	+	Policy Report (DigCompCons)	-	+	-	n.a.	n.a.
Calvani et al. (2008)	Digital Competence	+	Article	-	-	+	-	-
Carretero et al. (2017)	Digital Competence	+	Policy Report (DigComp)	-	n.a.	n.a.	n.a.	n.a.
Cartelli (2010)	Digital Competence	++	Conference Paper	-	-	+	-	-
Eshet-Alkalai (2004)	Digital Literacy	++	Literature Review	+	-	-	+	n.a.
Ferrari (2012)	Digital Competence	+	Policy Report (DigComp)	-	+	-	n.a.	n.a.
Ferrari (2013)	Digital Competence	+	Policy Report (DigComp)	-	+	-	n.a.	n.a.
Ferrari, Punie, & Redecker (2012)	Digital Competence	+	Conference Paper	-	-	-	†	†
Ferrari, Brečko, & Punie (2014)	Digital Competence	+	Policy Report (DigComp)	-	+	-	n.a.	n.a.
Gallardo-Echenique et al. (2015)	Digital Competence	-	Literature Review	-	-	-	†	†
Guzmán-Simón et al. (2017)	Digital Competence	-	Article	+	-	+	+	-
Hatlevik (2009)	Digital Competence	-	Article	-	-	+	+	-
Hatlevik (2015)	Digital Competence	-	Article	+	-	+	-	-

Hobbs (2010)	Digital and Media Literacy	-	Policy Report (White Paper)	-	-	-	†	†
Ilomäki et al. (2011)	Digital Competence	-	Literature Review	-	-	-	†	†
Janssen et al. (2013)	Digital Competence	++	Article	+	+	+	+	+
Maderick et al. (2016)	Digital Literacy	-	Article	+	-	+	+	+
Martin & Grudziecki (2006)	Digital Literacy	+	Literature Review (DigEULit)	-	-	-	†	†
Mengual-Andrés et al. (2016)	Digital Literacy	+	Article	-	-	+	+	+
Meyers et al. (2013)	Digital Literacy	-	Literature Review	+	-	-	†	†
Ng (2012)	Digital Competence	+	Article	+	+	+	+	-
Siiman et al. (2016)	Digital Competence	+	Conference Paper (DigComp)	-	-	+	-	-
Soldatova & Rasskazova (2014)	Digital Competence	++	Article	-	-	+	+	+
Torres-Coronas & Vidal-Blasco (2011)	Digital Skills	+	Literature Review	+	-	-	†	†
van Laar et al. (2017)	Digital Competence	+	Literature Review	+	-	-	†	†
Vieru (2015)	Digital Competence	+	Encyclopaedia	-	-	-	†	†

Note.

^a International Scientific Indexing

+ = *yes*, - = *no*, ++ = *new framework was proposed*, † = *no sample*, n.a. = *not available*

*This project aimed to develop and understand the concept of DC for European citizens

Table 2

Dimensions of digital competencies at work as the result of the clustering process from the literature review and interviews with practitioners.

Dimensions	Literature Cluster	Practice Cluster
1 Handling of hardware	-	Handling hardware
2 Handling of software	-	Handling software/ programmes
3 Programming	-	Programming
4 Handling of applications	-	Handling Office, Internet
5 Innovative capability and creativity	Creating content: creative, innovative	-
6 Information processing: Recognizing one's own knowledge gaps	-	Detecting lack of knowledge
7 Information processing: Search	Information processing: searching and finding	Search, research
8 Information processing: Data analysis	Information processing: analysing	-
9 Information processing: Evaluating	Information processing: evaluating	Data management: filtering
10 Data organisation	Data management	Storing data Organising data
11 Effective usage	Technical know-how: Ability to effectively use ICT	-
12 Communication	Communication	Communication
13 Collaboration	Collaboration	Virtual collaboration
14 Networking	-	Connectivity Networking
15 Netiquette	-	Dealing with each other
16 Sharing data with others	-	Sharing data with others

DIGITAL COMPETENCIES AT WORK

34

17	Cultural aspects	Cultural aspects	-
18	Security and law	Security	Security: awareness of danger, knowledge about security Legal basics/ fundamentals Privacy Data security/ safety
19	Responsibility	Responsibility	-
20	Goals and motivation	Motivation, goals, self-regulation capabilities, adjust actions to one's own goals	Attitude and motivation
21	Willingness to learn and openness	Learning, adaptability, change	Willingness/ readiness to learn Openness Adaptability
22	Ethics and moral	Ethics/ moral	-
23	Autonomy and independence	Autonomy/ independence	Self-management
24	Problem-solving	Problem-solving	Problem-solving Capability to learn Gather knowledge about problem-solving/ solution strategies Precaution Basic knowledge about problem-solving
25	Train/ educate others	-	Train/ educate others

Highlights

- integrate perspectives from science and practice on digital competencies at work
- Combine findings from extensive literature review and semi-structured interviews
- postulate a definition of digital competencies at work to foster understanding
- propose comprehensive framework with 25 dimensions of digital competencies at work